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Prevalence and risk of injury in Europe by driving with alcohol, illicit drugs and medicines

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Abstract

Prevalence and injury risk of driving with alcohol, illicit drugs and medicines have been estimated as part of the DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) project of FP6.
Prevalence in the driving population was based on roadside surveys in thirteen European countries, prevalence in seriously injured drivers and killed drivers on data from nine countries. Blood and/or saliva samples were collected and analysed for ethanol, amphetamines, cocaine, cannabis, illicit opiates, benzodiazepines, Z-drugs and medicinal opioids. The estimates were based on concentrations at and above equivalent cut-offs in blood and saliva, enabling the inclusion of both blood and saliva in the calculations. Drivers in traffic served as the control sample and seriously injured/killed drivers as the case sample for estimating the risk as calculated by means of odds ratios, adjusted for age and gender.
The alcohol prevalence (concentrations ≥ 0.1 g/L) was much higher than the prevalence of other drugs, with highest alcohol prevalence in all three study samples in the southern and western European countries. Combined alcohol/drug use and multiple drug use were far more common in accident-involved drivers than in drivers in traffic. The prevalence of other drugs was highest in the driving population in south Europe with THC as most common, whereas benzodiazepines dominated in the northern countries of Europe.
Based on data from all involved countries, the risk of being seriously injured or killed significantly exceeded 1 for alcohol concentrations ≥ 0.5 g/L and almost all other drugs. Odds ratios differ between age groups and countries, but overall, alcohol concentrations ≥ 1.2 g/L together with combined alcohol/drug use had the highest odds-ratios, followed by alcohol concentrations between 0.8 and 1.2 g/L and multiple drug use.

Keywords: Alcohol; drugs; medicines; car drivers; prevalence; risk of injury

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1. Introduction

1.1. Background

The use of psychoactive substances can influence people's motor and cognitive performance (OECD, 2010 and references therein), and, consequently, be a hazard to traffic safety. Alcohol is a well-known contributor to road accidents (Borkenstein et al., 1974, Elvik and Vaa, 2004, Assum, 2005, Krüger and Vollrath, 2004) but other substances, such as illicit drugs and psychoactive medicines, can also adversely affect the fitness to drive (Berghaus, 2011) and, therefore, endanger traffic safety.

1.2. Objectives

The objectives of this paper are to assess the prevalence in the general driving population in European countries and in drivers who have been seriously injured or killed in traffic accidents as well as to assess the risk of driving with alcohol, illicit drugs and medicinal drugs. Furthermore the objective is to reveal whether there are differences in prevalence and risk between countries.

In total thirteen countries took part in the study of prevalence in the general driving population, of which nine countries took part in the study of the prevalence of seriously injured/killed drivers. These nine countries also participated to the study on relative risk of serious injury/fatality while positive for psychoactive substances. The studies are part of the DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) project of FP6.

2. Material and method

The prevalence of alcohol and other drugs in the driving population was calculated in thirteen European countries, see **Table 1**, based on roadside surveys (Houwing et al., 2011). In total about 50,000 drivers from the driving population in the participating countries gave a saliva sample, a blood sample or both samples.

The prevalence of alcohol and other drugs in seriously injured and killed car drivers was calculated in nine countries, see **Table 1**, based on studies in hospitals in six countries of seriously injured car drivers and studies in four countries of killed car drivers (Isalberti et al., 2011). In total about 2500 injured drivers gave a blood sample and about 1000 blood samples from killed drivers that had been collected for the accident investigation were included.

A set of guidelines, both for the roadside surveys and the studies of seriously injured drivers were developed and were followed in the national setups of the studies, implying that all blood and saliva samples that were collected from the drivers in the studies were analysed with confirmation methods for the same number of substances.

The data collections followed these guidelines, in order to ensure that the roadside surveys consisted of a random sample of drivers at all times of the day and week in various locations spread out over the regions. As for seriously injured drivers, the guidelines recommended that all seriously injured drivers admitted to the participating hospitals that fulfilled a number of criteria were included in the study.

In order for the roadside survey to serve as the control sample and the data collected in the hospitals to serve as the case sample for estimating the risk as calculated by means of odds ratios of a case-control study, the regions for the two types of studies should cover the same areas in a country.

Table 1. Participating countries, study period and number of samples

Region	Country	Prevalence in the driving population Period (N)	Prevalence in injured drivers Period (N)	Prevalence in killed drivers Period (N)	Risk controls/cases
Northern Europe	Denmark	2008-2009 (3002)	2007-2010 (840)		3002/839
	Finland	2007-2009 (3841)	2008-2010 (54)		2706/54
	Finland			2006-2008 (483)	3841/478
	Norway	2008-2009 (9236)		2006-2008 (193)	9236/193
	Sweden	2008-2009 (6199)		2008 (157)	6199/156
Eastern Europe	Czech Republic	2008-2009 (2037)	2008-2010 (387)		1267/385
	Hungary	2008-2009 (2738)			
	Lithuania	2008-2009 (1264)			
	Poland	2007-2009 (4005)			
Southern Europe	Spain	2008-2009 (3174)	2008-2009 (676)		1086/676
	Italy	2008-2009 (1310)			
	Portugal	2008-2009 (3965)		2009 (285)	2641/285
Western Europe	Belgium	2008-2009 (2949)	2008-2010 (348)		2949/348
	The Netherlands	2007-2009 (4822)	2008-2010 (187)		4822/188

2.1. Data collected in the roadside surveys

A number of regions were selected for the studies in the various countries, depending on the willingness of the police to cooperate at the roadside in stopping drivers at random. Only drivers of passenger cars and vans (hereafter named drivers) aged 18 and above were included in the road side surveys. Drivers were stopped at all times of the day and night in various locations both in urban and rural roads. After being stopped by the police, standardised anonymous information on the drivers was gathered by research teams and a saliva and/or blood sample was collected. However, in most countries where saliva was collected, the alcohol concentration was based on a breathalyzer reading and converted to the equivalent blood concentration. The following information was mandatory: age, gender, type of vehicle, road type and time and date of the control. The study sample was weighted according to the national distribution of traffic in eight time periods of the week, in which the prevalence was assumed not to vary substantially. Weighted prevalence was calculated, including confidence intervals (95%).

2.2. Data collected from seriously injured drivers

Five hospitals were selected in Belgium and Denmark, two in Finland, four in Italy and Lithuania and three in the Netherlands, preferably in the same regions as the roadside surveys. Only drivers aged 18 and above were included in the study. The interval between accident and blood sampling had to be less than 3 hours in order for the toxicological analyses to reflect as much as possible the drug concentration at the time of the accident. Only drivers with a Maximum Abbreviated Injury Scale (MAIS) $\geq$ 2 or equivalent were included (AAAM, 2008). A MAIS score was not available in Denmark and Italy, but other criteria were considered to guarantee inclusion of patients with an injury severity equivalent to MAIS $\geq$ 2.

Standardised information on the patients and their accidents was gathered. The following information was mandatory: age, gender, type of vehicle and type of accident (single/multi vehicle), time and date of accident and of blood sampling, medication/fluids administered prior to blood sampling, MAIS-score. Since the study sample included all patients fulfilling the inclusion criteria, the prevalence was approximated to the proportion (percentage) of psychoactive substances.

2.3. Data collected from killed drivers

Information on drugs in killed drivers and vans was obtained from the blood samples that had been collected in connection to the accident investigation in four countries within a certain period, cf. **table 1**. Blood samples from killed drivers aged 18 and above obtained from traffic accidents in the study periods, as well as similar information as for the seriously injured patients formed the data material. The prevalence was approximated to the proportion (percentage) of psychoactive substances.

2.4. Calculation of the risk for a car driver of being seriously injured or killed in a road accident while positive for alcohol and other drugs psychoactive substances

The risk for a driver of getting seriously injured or killed in an accident while positive for a given substance was calculated as the ratio between the odds for a driver of being seriously injured/killed in an accident while positive for a given substance and the odds of being seriously injured/killed while negative. The odds ratios were calculated by means of logistic regression using the SAS 9.2 procedure *proc logistic* with 95% confidence intervals.

As the case study samples, the data from the hospital studies of seriously injured drivers and the study samples of killed drivers were used. As the control study samples, the data from the roadside surveys in the same countries, weighted for the national distribution of traffic in each of eight time periods of the week were used (Hels et al., 2011). The risk estimates were adjusted by gender, age and country. Six countries contributed to the study on the risk of getting seriously injured: Denmark, Finland, Lithuania, Italy, Belgium and the Netherlands. Four countries contributed to the study on the risk of getting killed: Finland, Norway, Sweden and Portugal.

In principle, data were only included from regions where both controls and cases were collected. However, additional control regions were included if the age and gender distribution was not significantly different from the regions where both study samples were collected. In the same way, additional case regions were included if the injury score distribution was not significantly different from the regions where both study samples were collected. For the number of cases and controls, see **table 1**.

2.5. Toxicological analyses

All blood- and saliva samples were analysed by means of fully validated methods for the same number of substances in all countries, cf. **table 2,** except for alcohol in countries where the breathalyzer reading was used. Whole blood samples were extracted using solid phase extraction (SPE) or liquid-liquid (LLE) extraction. Chromatographic separation was performed by gas chromatography (GC), High Performance liquid chromatography (HPLC) or Ultra Performance liquid chromatography (UPLC). Saliva samples were extracted using solid phase extraction (SPE) or liquid-liquid (LLE) extraction. Chromatographic separation was performed by gas chromatography (GC), High Performance liquid chromatography (HPLC), Ultra Performance liquid chromatography (UPLC) or liquid chromatography (LC). Detection was done by mass spectrometry (MS) or tandem mass spectrometry (MSMS). Proficiency test analyses of saliva and whole blood were carried out by all participating laboratories, resulting in a high quality of toxicological analyses in all countries.

As the information about whether a subject was positive for a substance or not, came from toxicological analyses of samples from both blood and saliva, it was crucial for this study that equivalent cut-offs for blood and saliva were developed in order to be able to compare the saliva-positive subjects with the blood-positive subjects, see **table 2.** This is not an ideal solution, but the best alternative taken the situation that it was not possible to collect blood in the road side controls in all countries.

These equivalent concentrations were developed in the DRUID project (Verstraete et al., 2011) and are a most important finding, that partly solves the problem of being able to compare results based on two different specimen being collected in the road side survey. This means that concentrations of both blood and saliva could be included in the prevalence calculations. Furthermore, it enables the calculation of relative risk based on saliva in the control study sample and blood in the case study sample. In countries where alcohol was based on breath, the conversion factor between breath and blood was set to 2100.

The following results are based on concentrations of the substances in question that are equal to or exceed the above-mentioned equivalent concentrations in blood and in saliva. If both a saliva sample and a blood sample were analysed, the concentration in blood was used for this sample. THCCOOH alone was left out since this metabolite cannot be found in saliva.

Table 2 Recommended equivalent cut-offs for the substances included in the studies

Substance	Whole blood (ng/mL)	Saliva (ng/mL)	Substance	Whole blood (ng/mL)	Saliva (ng/mL)
Ethanol	0.1 (g/L)	0.082 (g/L)			
6-AM	10	16	MDMA	20	270
Alprazolam	10	3.5	Methadone	10	22
Amphetamine	20	360	Methamphetamine	20	410
Benzoylecgonine	50	95	Morphine	10	95
Clonazepam	10	1.7	Nordiazepam	20	1.1
Cocaine	10	170	Oxazepam	50	13
Codeine	10	94	THC	1	27
Diazepam	140	5	Zolpidem	37	10
Flunitrazepam	5.3	1	Zopiclone	10	25
Lorazepam	10	1.1	Tramadol	50	480
MDA	20	220	7-amino-clonazepam	1	3.1
MDEA	20	270	7-amino-flunitrazepam	8.5	1

For the results of the toxicological findings, drugs were grouped according to their pharmacological characteristics. Substances of the same type were combined into substance groups (see **table 3**).

Table 3. Substance groups in the analyses of prevalence and risk

Substance group	Prevalence in the driving population	Prevalence in the injured population	Relative risk of injury
Alcohol	x	x	x
Amphetamines, methamphetamines and MDA, MDEA and MDMA	x	x	x
Benzoylecgonine	x	x	x
Cocaine (cocaine or cocaine + benzoylecgonine)			x
THC (THC or THC + THCCOOH)	x	x	x
Illicit opiates	x	x	x
Benzodiazepines	x	x	x
Z-drugs	x	x	
Medicinal opioids	x	x	x
Alcohol and drug(s)	x	x	x
Multiple drugs	x	x	x

As for the toxicological findings in seriously injured drivers, in case the blood sample was positive for a drug that corresponded to the medicine administered before the blood sample was taken, then this concentration was considered negative.

3. Results

3.1. Prevalence of psychoactive substances in the driving population

Tables 4 and 5 show the prevalence for the various psychoactive substances and their combinations in the driving population in the countries involved, including confidence intervals. For some of the substance groups, the prevalence was too low to be calculated.

Highest prevalence in general was found for alcohol, with highest prevalence in the southern and western countries of Europe (2.15%-8.59%). As shown in the tables, there were big differences between the prevalence in the various countries. However, it should be noted that the data collection in Finland showed bias towards a high non-response rate of alcohol positive drivers, resulting in a too low prevalence, whereas the data collection in Italy showed a preference towards including drivers with signs of alcohol impairment. Finally drivers who were stopped at the roadside in the Swedish survey and registered positive for alcohol above the Swedish alcohol limit were not allowed to be included in the control sample by the police.

The prevalence in the driving population of medicinal drugs was higher in the northern countries (1.12%-1.71%) whereas the prevalence of illicit drugs was higher in the southern countries of Europe, especially Spain (7.63%).

However, regarding the prevalence of medicines in northern Europe, there were differences in the prevalence between the four countries for the different types of medicines analysed for. In eastern Europe the prevalence of alcohol, illicit drugs as well as medicinal drugs was relatively low compared to the other European regions. Combined use of alcohol and drugs and multiple drug use were more common in the southern countries of Europe.

THC was the most frequently detected illicit drug in the driving population, followed by cocaine. Amphetamines and illicit opiates were less frequently detected. Illicit drugs were in general mainly detected among young male drivers, during all times of the day but mainly during the weekend.

Table 4. Prevalence of alcohol and other psychoactive substances in the general driving population in northern and eastern Europe, including confidence intervals (95%)

	North				East			
	DK	**FI**	**NO**	**SE**	**CZ**	**HU**	**LT**	**PL**
Alcohol alone	2.53	0.64	0.32	n.a.	0.99	0.15	3.86	1.47
	2.02 - 3.15	*0.43 - 0.94*	*0.23 - 0.46*		*0.65 - 1.53*	*0.06 - 0.38*	2.93 - 5.06	*1.14 - 1.9*
Illicit drugs alone	0.22	0.12	0.60	0.10	0.82	0.23	0.22	0.71
	0.10 – 0.46	*0.06 – 0.30*	*0.46 – 0.78*	*0.04 – 0.21*	*0.51 – 1.31*	*0.11 – 0.49*	*0.07 – 0.66*	*0.49 – 1.02*
Amphetamines	0.02	0.05	0.06	0.07	0.36	-	0.22	0.05
	0 - 0.16	*0.02 - 0.19*	*0.02 - 0.13*	*0.03 - 0.17*	*0.17 - 0.72*	-	0.07 - 0.66	*0.01 - 0.18*
Cocaine	-	0.03	0.06	-	-	0.04	-	-
	-	*0.01 - 0.16*	*0.03 - 0.14*	-	-	*0.01 - 0.21*	-	-
THC	0.20	0.04	0.48	0.03	0.46	0.19	-	0.57
	0.09 - 0.43	*0.01 - 0.17*	*0.36 - 0.64*	*0.01 - 0.12*	*0.25 - 0.86*	*0.08 - 0.44*	-	*0.38 - 0.85*
Illicit opiates	-	-	-	-	-	-	-	0.09
	-	-	-	-	-	-	-	*0.04 - 0.25*
Medicinal drugs alone	1.58	1.71	1.69	1.12	0.83	1.68	1.41	0.17
	1.19 - 2.09	*1.35 - 2.17*	*1.45 - 1.98*	*0.89 - 1.42*	*0.52 - 1.33*	*1.26 - 2.23*	*0.9 - 2.23*	*0.08 - 0.35*
Benzodiazepines	0.47	0.79	0.84	0.19	0.62	1.50	1.41	0.14
	0.28 - 0.79	*0.56 - 1.13*	*0.67 - 1.05*	*0.11 - 0.33*	*0.36 - 1.07*	*1.11 - 2.03*	0.9 - 2.23	*0.06 - 0.31*
Z-drugs	0.32	0.36	0.69	0.31	-	0.07	-	-
	0.17 - 0.59	*0.21 - 0.6*	*0.54 - 0.88*	*0.2 - 0.48*	-	*0.02 - 0.26*	-	-
Medicinal opioids	0.79	0.56	0.16	0.63	0.21	0.11	-	0.03
	0.53 - 1.18	*0.37 - 0.85*	*0.1 - 0.27*	*0.46 - 0.86*	*0.08 - 0.52*	*0.04 - 0.32*	-	*0.01 - 0.15*
Alcohol-Drug combination	0.1	0.08	0.07	n.a.	0.05	-	0.03	-
	0.03 - 0.3	*0.03 - 0.23*	*0.03 - 0.15*		*0.01 - 0.28*	-	0 - 0.36	-
Drug-Drug combination	0.06	0.29	0.28	0.12	0.11	0.27	-	0.02
	0.02 - 0.24	*0.16 - 0.52*	*0.19 - 0.42*	*0.06 - 0.25*	*0.03 - 0.38*	*0.13 - 0.54*	-	*0 - 0.14*

Table 5. Prevalence of alcohol and other psychoactive substances in the general driving population in southern and western Europe, including confidence intervals (95%)

European region	**South**			**West**	
Country	**ES**	**IT**	**PT**	**BE**	**NL**
Alcohol alone	3.92	8.59	4.93	6.42	2.15
	3.3 - 4.66	*7.19 - 10.23*	*4.29 - 5.64*	*5.59 - 7.36*	*1.78 - 2.6*
All illicit drugs alone	7.63	2.70	1.57	0.64	2.16
	6.76 – 8.61	*1.95 – 3.73*	*1.23 – 2.01*	*0.41 – 1.00*	*1.79 – 2.61*
Amphetamines	0.11	-	-	-	0.19
	0.04 - 0.3	-	-	-	*0.1 - 0.36*
Cocaine	1.49	1.25	0.03	0.20	0.30
	1.12 - 1.97	*0.78 - 2.01*	*0.01 - 0.16*	*0.09 - 0.43*	*0.18 - 0.5*
THC	5.99	1.15	1.38	0.35	1.67
	5.22 - 6.87	*0.7 - 1.89*	*1.07 - 1.8*	*0.19 - 0.64*	*1.34 - 2.07*
Illicit opiates	0.05	0.30	0.15	0.09	0.01
	0.01 - 0.2	*0.12 - 0.78*	*0.07 - 0.33*	*0.03 - 0.28*	*0 - 0.09*
All medicinal drugs alone	1.59	1.50	2.84	2.99	0.60
	1.21 - 2.09	*0.97 - 2.31*	*2.37 - 3.41*	*2.43 - 3.66*	*0.42 - 0.87*
Benzodiazepines	1.40	0.97	2.73	2.01	0.40
	1.05 - 1.87	*0.57 - 1.67*	*2.27 - 3.29*	*1.57 - 2.59*	*0.25 - 0.62*
Z-drugs	-	-	-	0.22	0.04
	-	-	-	*0.1 - 0.47*	*0.01 - 0.15*
Medicinal opioids	0.19	0.53	0.11	0.75	0.16
	0.09 - 0.41	*0.25 - 1.09*	*0.04 - 0.27*	*0.5 - 1.13*	*0.08 - 0.32*
Alcohol-drug combinations	1.14	1.01	0.42	0.31	0.24
	0.83 - 1.58	*0.59 - 1.71*	*0.26 - 0.67*	*0.16 - 0.58*	*0.13 - 0.42*
Drug-drug combinations	0.57	1.22	0.23	0.30	0.35
	0.36 - 0.89	*0.75 - 1.97*	*0.12 - 0.44*	*0.16 - 0.58*	*0.22 - 0.56*

The group of benzodiazepines was the most prevalent medicinal drug in drivers in the general traffic, Z-drugs were less prevalent. However, considerable differences between countries were observed. Medicinal drugs were in general mainly detected among older female drivers during daytime hours.

3.2. Prevalence of psychoactive substances in seriously injured and killed drivers

Table 6 shows the prevalence for the various psychoactive substances alone and the prevalence of combined use in seriously injured and killed drivers in the countries involved, sorted by European region. Furthermore, **table 7** shows the percentages of samples that were positive for a substance group in combination with one or more other substance groups.

The prevalence of alcohol alone varied between 15 and 30% except for Portugal (38.9%). Alcohol in combination with other drugs was found in about 13% of the samples in Belgium down to about 2% in Lithuania. Among the positive drivers – both seriously injured and killed, the majority had a blood alcohol concentration equal to or above 0.5 g/L; the median concentration was 1.6 g/L.

The prevalence of illicit drugs varied between the countries with considerable combined use of various substances. Furthermore, the following remarks characterize illicit drug use: Amphetamine use appeared to be more common in northern Europe, both for seriously injured and killed drivers. In Portugal, no killed drivers were positive for amphetamines. Cocaine use seemed to be more prevalent in southern Europe and for killed drivers in Sweden. In Finland neither any seriously nor killed drivers were positive for cocaine.

Medicinal opioids were found in all countries, with a maximum for seriously injured drivers in Lithuania (app 6% alone and 2% in combination with other drugs) and a minimum in the Netherlands (app 0.5%, only found alone). Lithuania had almost a double percentage of seriously injured drivers who were positive for medicinal opioids (close to 6%), compared to the other five countries. Similarly, Sweden had a double percentage of killed drivers who were positive for medicinal opioids compared with the other three countries.

Table 6. Percentage of seriously injured and killed drivers positive for substance groups alone or their combinations

	Seriously injured drivers						Killed drivers			
European region	**North**		**East**	**South**	**West**		**North**			**South**
Country	**DK**	**FI**	**LT**	**IT**	**BE**	**NL**	**FI**	**NO**	**S**	**PT**
Alcohol alone	14.1	25.5	15.3	18.5	30.2	25.3	24.4	18.2	15.6	38.9
All illicit drugs alone	1.6	1.9	1.1	3.6	2.4	2.7	0.7	3.0	3.4	0
Amphetamines	1.0	0	0.3	0	0.9	1.1	0.7	1.2	2.1	0
Cocaine	0	0	0.6	1.3	0	1.1	0	0	0	0
THC	0.6	2.1	0.3	1.6	1.5	0.5	0	1.8	0.7	0
Illicit opiates	0	0	0	0.7	0	0	0	0	0	0
All medicinal drugs alone	4.2	1.9	8.0	2.2	4.2	1.0	8.6	3.6	3.5	1.4
Benzodiazepines	1.2	0	2.3	0.4	1.5	0	5.2	1.8	0	0.7
Z-drugs	0.5	2.1	0	0	0.9	0.5	1.7	1.2	2.8	0
Medicinal opioids	2.5	0	5.7	1.8	1.2	0.5	1.5	0.6	0.7	0.7
Alcohol-Drug combination	5.4	10.6	2.3	4.6	13.2	4.3	7.2	7.9	4.3	6.0
Drug-Drug combination	3.5	4.3	0.8	2.5	2.5	0.5	1.5	7.3	4.3	0.4
Positive samples in total	28.8	44.2	27.5	31.4	52.5	33.8	42.4	40.0	31.1	46.7

Table 7 Percentage of seriously injured drivers positive for one substance group in combination with other substance groups

	Seriously injured drivers						Killed drivers			
European region	**North**		**East**	**South**	**West**		**North**			**South**
Country	**DK**	**FI**	**LT**	**IT**	**BE**	**NL**	**FI**	**NO**	**S**	**PT**
Amphetamines	3.2	3.7	0.3	0.1	1.7	1.1	1.5	6.3	3.9	0
Cocaine	1.3	0	0	4.2	3.8	3.7	0	0.6	1.3	1.4
THC	0.7	3.8	0.3	2.1	6.1	0	1.3	4.5	0.7	0
Illicit opiates	0.5	0	0.3	1.3	0.6	0	0	0	0	0
Benzodiazepines	5.5	10.2	1.3	0.3	5.8	0	7.9	8.0	3.9	1.1
Z-drugs	0.7	1.9	0	0	0.9	0	1.3	2.7	0.6	0
Medicinal opioids	1.7	2.0	2.1	1.9	1.5	0	0.6	1.1	2.7	1.4

3.3. Risk of getting seriously injured or killed

Risk estimates based on data from several countries for seriously injured drivers and killed drivers are shown in **table 8 and 9**. Both crude odds ratios as well as odds ratios adjusted for gender, age and country were calculated. However, as indicated in **tables 8 and 9**, Finland and Italy were left out of the risk calculation regarding alcohol due to suspected bias in the data collection of drivers at the roadside, and Sweden because alcohol positive drivers were not included in the control sample, see section 3.1.

As seen from **table 8** and **9**, the main problem is high alcohol concentrations and alcohol combined with other psychoactive substances. Other high risk groups are medium alcohol concentrations 0.8-1.2, multiple drug use and amphetamines. Medium increased risk was found for alcohol concentrations 0.5 - 0.8 g/L, for cocaine and for the medicinal drug groups included in the study. The risk associated with benzoylecgonine that is not an active agent might be caused by sleep deprivation after cocaine consumption. Furthermore, the risk associated with THC seems to be similar to the risk when driving with a low alcohol concentration. The risk estimates for some of the illicit drugs vary to a high degree among the single countries whereas risk estimates for other illicit drugs are based on few positive samples with the result of very wide confidence intervals. Therefore the risk estimates for illicit drugs should be handled with care. Young drivers aged 18-24 had the highest risk. For seriously injured drivers, the risk was lowest in the Netherlands and Finland and highest in Italy. For killed driver, it was lowest in Norway and highest in Finland and Portugal. The trend was the same for all substance groups.

Table 8. Risk (odds ratio) for a driver of getting seriously injured while positive for various substances including confidence intervals (95%). Crude OR and OR adjusted for gender, age and country.

Substance group	Countries	Crude OR	C.I.	Adjusted OR	C.I.
Negative (reference)		1.00		1.00	
All alcohol	DK, LT, BE, NL	7.55	*6.47-8.80*	9.79	*8.18-11.72*
0.1g/L≤alcohol<0.5g/L	DK, LT, BE, NL	(1.05)	*0.73-1.53*	(1.30)	*0.88-1.94*
0.5g/L≤alcohol<0.8g/L	DK, LT, BE, NL	3.80	*2.48-5.82*	4.18	*2.58-6.77*
0.8/L≤alcohol<1.2g/L	DK, LT, BE, NL	13.97	*8.75-22.29*	16.48	*9.64-28.18*
Alcohol≥1.2g/L	DK, LT, BE, NL	55.27	*39.52-77.31*	77.76	*54.11-111.74*
All illicit drugs alone	DK, FI, IT, LT, BE, NL	2.87	*2.12-3.89*	2.68	*1.88-3.82*
Amphetamines	DK, FI, IT, LT, BE, NL	9.66	*4.80-19.46*	14.15	*5.82-34.42*
Benzoylecgonine	DK, FI, IT, LT, BE, NL	5.36	*2.53-11.34*	3.88	*1.41-10.68*
Cocaine	DK, FI, IT, LT, BE, NL	3.41	*1.61-7.21*	(1.65)	*0.66-4.16*
THC	DK, FI, IT, LT, BE, NL	1.86	*1.20-2.88*	1.91	*1.15-3.17*
Illicit opiates	DK, FI, IT, LT, BE, NL	4.03	*1.32-12.32*	(1.18)	*0.23-5.99*
All medicinal drugs alone	DK, FI, IT, LT, BE, NL	3.60	*2.84-4.57*	3.60	*2.74-4.74*
Benzodiazepines and Z-drugs	DK, FI, IT, LT, BE, NL	1.73	*1.19-2.51*	1.77	*1.16-2.69*
Medicinal opioids	DK, FI, IT, LT, BE, NL	7.99	*5.73-11.15*	7.37	*4.99-10.88*
Alcohol-Drug combination	DK, LT, BE, NL	31.97	*20.76-49.25*	39.15	*24.21-63.31*
Drug-Drug combination	DK, FI, IT, LT, BE, NL	8.64	*5.85-12.75*	7.02	*4.38-11.24*

Table 9. Risk (odds ratio) for a driver of getting killed while positive for various substances, including confidence intervals (95%). Crude OR and OR adjusted for gender, age and country.

Substance group	Countries	Crude OR	C.I.	Adjusted OR	C.I.
Negative (reference)		1.00		1.00	
All alcohol	N, PT	37.64	*29.36-48.24*	19.00	*14.43-25.03*
0.1g/L≤alcohol<0.5g/L	N, PT	9.23	*6.07-14.05*	3.62	*2.32-5.65*
0.5g/L≤alcohol<0.8g/L	N, PT	42.94	*21.99-83.86*	22.96	*11.24-46.91*
0.8/L≤alcohol<1.2g/L	N, PT	34.81	*16.02-75.65*	19.97	*8.52-46.77*
Alcohol≥1.2g/L	N, PT	450.37	*224.06-905.25*	353.11	*164.63-757.40*
All illicit drugs alone	FI, N, S, PT	3.85	*2.17-6.80*	3.59	*1.95-6.60*
Amphetamines	FI, N, S, PT	25.44	*10.81-59.90*	34.34	*13.18-89.49*
Benzoylecgonine	FI, N, S, PT	6.87	*1.49-31.76*	-	-
Cocaine	FI, N, S, PT	22.34	*3.66-136.53*	-	-
THC	FI, N, S, PT	(1.80)	*0.73-4.44*	(1.25)	*0.45-3.51*
Illicit opiates	FI, N, S, PT	10.04	*2.04-49.32*	-	-
All medicinal drugs alone	FI, N, S, PT	5.05	*3.80-6.72*	4.47	*3.31-6.05*
Benzodiazepines and Z-drugs	FI, N, S, PT	5.11	*3.72-7.02*	4.59	*3.28-6.43*
Medicinal opioids	FI, N, S, PT	4.82	*2.61-8.88*	4.07	*2.14-7.72*
Alcohol-Drug combination	N, PT	41.22	*22.59-75.24*	25.19	*13.06-48.59*
Drug-Drug combination	FI, N, S, PT	16.77	*9.95-28.27*	24.42	*13.79-43.25*

4. Conclusions

Alcohol and illicit drugs in the general driving population were more prevalent in southern and western Europe whereas medicines were more prevalent in northern Europe. These findings are in line with the prevalence of psychoactive substances in the general population (Ravera and de Gier 2008).

Alcohol was most prevalent both for seriously injured and killed drivers, with the blood alcohol concentration ≥ 0.5 g/L in about 90% of the samples. In both studies, the majority of illicit and medicinal drugs appeared to be used in combination with other psychoactive substances. Among the illicit drugs, amphetamine use appeared to be more common in northern Europe, while cocaine use seemed to be more prevalent in southern Europe. Compared to the present study, former studies found even higher prevalence of benzodiazepines and cannabis in injured drivers (Mura 2003, Assum et al. 2005).

High alcohol concentrations and the combination of alcohol and other drugs showed the highest risk and reflect that in contrary to the driving population, alcohol was found in high concentrations in accident involved drivers. These findings are in line with previous case-control studies (Borkenstein et al. 1974, Krüger and Vollrath 2004, Mathijssen and Houwing 2005) that showed that the accident and injury risk increases drastically at high BAC levels.

Emphasis should also be on the high risk for multiple drug use that was much more common in accidents than in drivers in traffic. In general, the risk of the various drug groups show values that are significantly above 1.

Appendix A. Participating institutions in the project and disclaimer

Apart from the authors' institutions, the following institutions participated in the studies: Section of Forensic Chemistry, Department of Forensic Medicine, University of Copenhagen, Denmark, National Institute for Health and Welfare, Alcohol and Drug Analytics Unit, Finland, Norwegian Institute of Public Health, Swedish National Road and Transport Research Institute, State Forensic Medicine Service under the Ministry of Justice of the Republic of Lithuania, University of Padova, Italy, National Institute of Legal Medicines, Portugal and Institut Belge pour la Sécurité Routière. The paper has been produced under the IP DRUID of the EU 6th Framework Program and reflects only the authors' view. The European Commission is not liable for any use of the information contained therein.

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